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Second edition
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Optics and photonics — Environmental test methods —

Part 23: Low pressure combined with cold, ambient temperature and dry or damp heat

Optique et photonique — Méthodes d'essais d'environnement —

Partie 23: Basse pression combinée à la température ambiante et froide et à la chaleur sèche ou humide

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 172 *Optics and photonics*, Subcommittee SC 1 *Fundamental standards*.

This second edition cancels and replaces the first edition (ISO 9022-23:2013), which has been undergone a minor revision to reflect the changes made to the ISO 9022 series. The term "low pressure" is now used throughout the whole document where previously the term "low air pressure" was used.

ISO 9022 consists of the following parts, under the general title *Optics and photonics — Environmental test methods*:

— *Part 1: Definitions, extent of testing*

— *Part 2: Cold, heat and humidity*

— *Part 3: Mechanical stress*

— *Part 4: Salt mist*

— *Part 6: Dust*

— *Part 7: Resistance to drip or rain*

— *Part 8: High internal pressure, low internal pressure, immersion*

— *Part 9: Solar radiation and weathering*

— *Part 11: Mould growth*

— *Part 12: Contamination*

— *Part 14: Dew, hoarfrost, ice*

— *Part 17: Combined contamination, solar radiation*

— *Part 20: Humid atmosphere containing sulfur dioxide or hydrogen sulfide*

— *Part 22: Combined cold, dry heat or temperature change with bump or random vibration*

— *Part 23: Low pressure combined with cold, ambient temperature and dry or damp heat*

Introduction

Optical instruments are affected during their use by a number of different environmental parameters which they are required to resist without significant reduction in performance and to remain within defined specifications.

The type and severity of these parameters depend on the conditions of use of the instrument (for example, in the laboratory or workshop) and on its geographical location. The environmental effects on optical instrument performance in the tropics and subtropics are totally different from those found when they are used in arctic regions. Individual parameters cause a variety of different and overlapping effects on instrument performance.

The manufacturer attempts to ensure, and the user naturally expects, that instruments will resist the likely rigours of their environment throughout their life. This expectation can be assessed by exposure of the instrument to a range of simulated environmental parameters under controlled laboratory conditions. The severity of these conditions is often increased to obtain meaningful results in a relatively short period of time.

In order to allow assessment and comparison of the response of optical instruments to appropriate environmental conditions, ISO 9022 contains details of a number of laboratory tests which reliably simulate a variety of different environments. The tests are based largely on IEC standards, modified where necessary to take into account features special to optical instruments.

As a result of continuous progress in all fields, optical instruments are no longer only precision-engineered optical products, but, depending on their range of application, also contain additional assemblies from other fields. For this reason, the principal function of the instrument is to be assessed to determine which International Standard should be used for testing. If the optical function is of primary importance, then ISO 9022 is applicable, but if other functions take precedence, then the appropriate International Standard in the field concerned should be applied. Cases may arise where application of both ISO 9022 and other appropriate International Standards will be necessary.

Optics and photonics — Environmental test methods —

Part 23:
Low pressure combined with cold, ambient temperature and dry or damp heat

1 Scope

This part of ISO 9022 specifies the methods relating to the environmental tests of optical instruments including additional assemblies from other fields (e.g. mechanical, chemical, and electronic devices), under equivalent conditions, for their ability to resist the influence of low pressure combined with cold, including the potential condensation and freezing of moisture, ambient temperature, and dry or damp heat.

This part of ISO 9022 is applicable to optical instruments including additional assemblies from other fields, designed for operation and/or transport in high mountainous areas or on board aircraft or missiles.

The purpose of the testing is to investigate to what extent optical, climatic, mechanical, chemical, and electrical (including electrostatic) performance characteristics of the specimen are affected by combined low pressure and low, ambient, or high temperature. Furthermore, the additional effects of moisture condensing and freezing on the instrument or components can be determined. Examples are instruments which are installed or externally mounted on aircraft or missiles or transported inside aircraft or flying objects not providing any pressure equalization.

Annex A explains the intent of the different types of tests.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9022-1, *Optics and photonics — Environmental test methods — Part 1: Definitions, extent of testing*

ISO 9022-8, *Optics and photonics — Environmental test methods — Part 8: High internal pressure, low internal pressure, immersion*

3 General information and test conditions

Ambient temperature as understood by this part of ISO 9022 is (23 ± 3) °C.

The values of temperatures and climatic conditions specified in Table 1 to Table 6 are selected from ISO 9022-2, conditioning methods 10, 11, and 12.

The size of the test chamber and the setup of the specimens shall be chosen in such a way that a uniform temperature for all specimens within the test chamber is ensured.

For conditioning methods 45, 46, 50, and 51, air circulation in low-pressure cabinets or low-pressure chambers is required. The low-pressure chamber, itself, can either be equipped as a thermal chamber or be installed in a thermal chamber.

For conditioning methods 47 to 49, a climatic test chamber is required. Three different test methods are used to test combined damp heat and low internal pressure resistance of optical instruments. Dew on the specimen is admissible. The individual test steps shall be performed directly one after another. Interruption of the test is not admissible.

In addition for conditioning method 47, if condensation is produced, the specimens shall be protected against falling drops.

In addition for conditioning method 48, a low-pressure container is also required.

In addition for conditioning method 49, the specimens shall have a test connection for evacuation and pressure measurement, as described in ISO 9022-8.

Changes in temperature shall be effected sufficiently slowly not to cause any damage to the specimen. Shock-type air pressure changes shall be avoided unless they are likely to be encountered in the natural environment.

4 Conditioning

4.1 Conditioning method 45 — Low ambient pressure combined with ambient temperature

See Table 1.

Table 1 — Degrees of severity for conditioning method 45 — Low ambient pressure combined with ambient temperature

Degree of severity		**01**	**02**	**03**	**04**
Test chamber temperature	°C	23 ± 3	23 ± 3	23 ± 3	23 ± 3
Test chamber pressure	hPa	800 ± 30	700 ± 30	600 ± 30	500 ± 30
Time of pressure reduction and pressure increase	min	≤ 15			
Period of conditioning	h	≥ 1[a]			
State of operation		2	2	2	2

[a] With thermally active specimens after the steady-state temperature of the specimen has been reached.

4.2 Conditioning method 46 — Low ambient pressure combined with dry heat

See Table 2.

Table 2 — Degrees of severity for conditioning method 46 — Low ambient pressure combined with dry heat

Degree of severity		01	02	03	04	05	06	07	08	09	10	11	12
Test chamber temperature	°C	40 ± 3	40 ± 3	55 ± 3	55 ± 3	63 ± 3	63 ± 3	85 ± 3[a]	85 ± 3[a]	40 ± 3	55 ± 3	63 ± 3	85 ± 3[a]
Test chamber pressure	hPa	100 ± 5								10 ± 1			
Time of pressure reduction and pressure increase	min	≤ 15								≤ 80			
Mean temperature change during heating/cooling	K/min	0,2 to 2											
Exposure time	h	24	72	24	72	24	72	24	72	24	24	24	24
State of operation		1 or 2											

[a] State of operation 1 only.

4.3 Conditioning method 47 — Low internal pressure combined with damp heat, pressure difference low

See Table 3 and Figure 1.

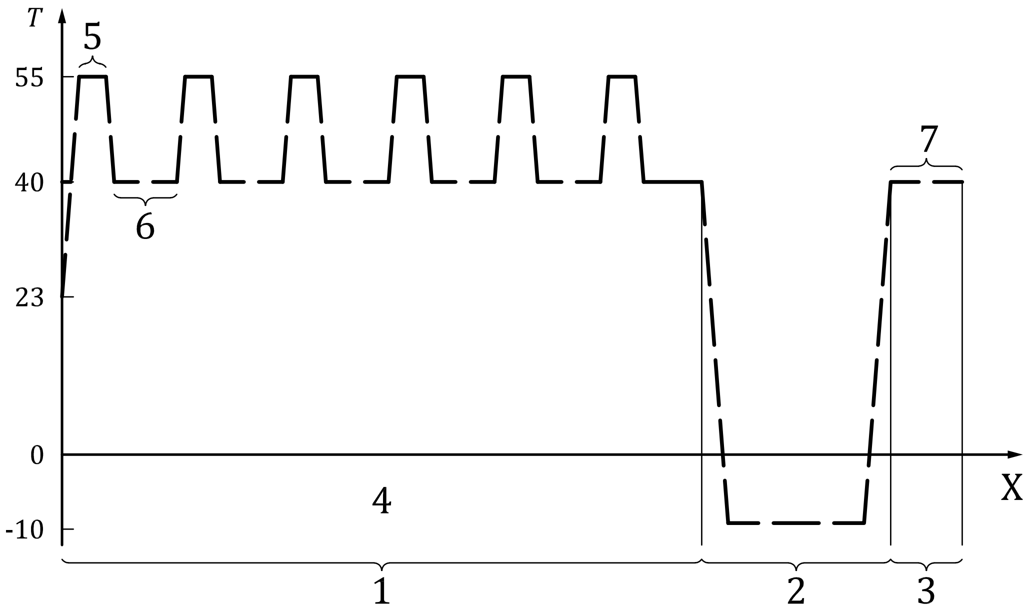
Conditioning method 47 shall be used for optical instruments where demands made on their sealing (low pressure resistance) are low, e.g. instruments which comply with the requirements of the degrees of severity 01, 02, 07, and 08 of conditioning method 81 in ISO 9022-8.

Table 3 — Degrees of severity for conditioning method 47 — Low internal pressure combined with damp heat, pressure difference low

Degree of severity				01	02	03	04	05	06
Condition 1	Step 1	Test chamber temperature	°C	55 ± 2		63 ± 2		70 ± 2	
		Relative humidity	%	< 40					
		Exposure time	h	Until the internal air of the specimen has reached a temperature at least within 3 K of the test chamber temperature.					
	Step 2	Climatic conditions		40 °C ± 2 °C and 90 % to 95 % relative humidity.					
		Exposure time	h	≥ 1					
	Number of cycles			6	12	6	12	6	12
Condition 2	Test chamber temperature		°C	−10 ± 3					
	Exposure time		h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.					

Table 3 *(continued)*

Condition 3	Test chamber temperature	°C	40 ± 2
	Relative humidity	%	< 40
	Exposure time	h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.
State of operation			1



Key

1 condition 1
2 condition 2
3 condition 3
4 duration according to Table 1
5 relative humidity, < 40 %
6 relative humidity, 90 % to 95 %
7 relative humidity, < 40 %
X duration, h
T temperature, °C

Figure 1 — Cycling curve for conditioning method 47, using example of degree of severity 01

4.4 Conditioning method 48 — Low internal pressure combined with damp heat, pressure difference medium

See Table 4.

Conditioning method 48 shall be used for optical instruments where demands made on their sealing (low pressure resistance) are medium, e.g. instruments which comply with the requirements of the degrees of severity 03, 04, 09, and 10 of conditioning method 81 in ISO 9022-8.

Table 4 — Degrees of severity for conditioning method 48 — Low internal pressure combined with damp heat, pressure difference medium

Degree of severity				01	02	03	04	05	06
Condition 1	Step 1	Test chamber temperature	°C	40 ± 2					
		Test chamber pressure	hPa	800		650		500	
		Exposure time	h	≥ 1					
	Step 2	Climatic conditions		40 °C ± 2 °C and 90 % to 95 % relative humidity.					
		Exposure time	h	≥ 1,5					
	Number of cycles			3	6	3	6	3	6
Condition 2	Test chamber temperature		°C	−10 ± 3					
	Exposure time		h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.					
Condition 3	Test chamber temperature		°C	40 ± 2					
	Relative humidity		%	< 40					
	Exposure time		h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.					
State of operation				1					

4.5 Conditioning method 49 — Low internal pressure combined with damp heat, pressure difference high

See Table 5.

Conditioning method 49 shall be used for optical instruments where demands made on their sealing (low pressure resistance) are high, e.g. instruments which comply with the requirements of the degrees of severity 05, 06, 11, 12, and 13 of conditioning method 81 in ISO 9022-8.

Table 5 — Degrees of severity for conditioning method 49 — Low internal pressure combined with damp heat, pressure difference high

Degree of severity			01	02	03	04	05	06
Condition 1	Climatic conditions		40 °C ± 2 °C and 90 % to 95 % relative humidity.					
	Constant pressure reduction in specimen interior with respect to surrounding pressure	hPa	200		350		500	
	Exposure time during constant pressure reduction	h	≥ 1					
Condition 2	Climatic conditions		40 °C ± 2 °C and 90 % to 95 % relative humidity.					
	Exposure time after termination of constant pressure reduction (vacuum pump disconnected)	h	≥ 4				≥ 6	
Condition 3	Test chamber temperature	°C	−10 ± 3					
	Exposure time	h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.					
Condition 4	Test chamber temperature	°C	40 ± 2					
	Relative humidity	%	< 40					
	Exposure time	h	Until specimen has reached a temperature at least within 3 K of the test chamber temperature.					
State of operation			1					

4.6 Conditioning method 50 — Low ambient pressure combined with cold, including hoarfrost and dew

Degrees of severity 01 to 08 shall be applicable, as specified in Table 6.

4.7 Conditioning method 51 — Low ambient pressure combined with cold, without hoarfrost and dew

Degrees of severity 01 to 04, 06 and 07 shall be applicable, as specified in Table 6.

Table 6 — Degrees of severity for conditioning methods 50 and 51 — Low ambient pressure combined with cold

Degree of severity			**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**
Test chamber temperature		°C	−25 ± 3	−40 ± 3	−25 ± 3	−40 ± 3	−65 ± 3	−25 ± 3	−40 ± 3	−65 ± 3
Test chamber pressure		hPa	600 ± 30		85 ± 10			10 ± 5		
	Equivalent altitude[a]	m	3 500		16 000			31 000		
Time of pressure reduction and pressure increase		min	max. 5		max. 20			max. 40		
Mean temperature change during heating/cooling		K/min	In the range of 0,2 to 2							
Exposure time		h	4							
State of operation			1 or 2							

[a] The data are based on bad weather conditions.

5 Procedure

5.1 General

The test shall be conducted in accordance with the requirements of the relevant specification and with ISO 9022-1.

See Annex A for explanatory notes of conditioning methods 47 to 51 and an example of conditioning method 50.

5.2 Procedure for conditioning method 45

With conditioning method 45, the thermally active specimen (unless the relevant specification stipulates otherwise) shall be put into operation after the test pressure has been reached. These specimens shall be subjected to the test pressure until the temperature of the specimen increases by no more than 1 K within 1 h (steady-state temperature).

When the pressure is rising, no condensation shall occur on the specimen. Ways of preventing this are either the use of repurified nitrogen or dry air for the ventilation of the test chamber or radiant heating of the specimen.

5.3 Procedure for conditioning method 46

To achieve the test temperature, heating shall be started before the pressure is reduced. The specimen shall have reached the specified test temperature before the test pressure is adjusted. Thermally active specimens shall be subjected to the test temperature until the temperature of the specimen changes not more than 1 K/h during constant test chamber temperature. Then, pressure reduction shall be started. Intrinsic heating of the specimen during this procedure shall be admissible.

The period of conditioning shall start when all parts of the specimen have reached a temperature within 3 K of the test chamber temperature and the specified pressure has been reached.

After completion of conditioning, the rise in pressure is initiated simultaneously to the cooling down of the test chamber to ambient temperature. The temperature shall be measured in the test chamber and on the specimen. The location of the temperature sensor on the specimen shall be specified in the relevant specification. The location of the temperature sensor for measuring the chamber air temperature shall be noted in the test report.

When the pressure is rising, no condensation shall occur on the specimen. Ways of preventing this are either the use of repurified nitrogen or dry air for the ventilation of the test chamber or radiant heating of the specimen.

5.4 Procedure for conditioning method 47

5.4.1 Initial and final inspection

A visual inspection shall be performed with a ×4 to ×10 magnification against a dark background. The illumination during the check shall be provided by an illumination device providing 5 000 lx through a collimated light source or gooseneck fibre bundle light source with a daylight-equivalent colour temperature. Subsequent to 24 h storage at room temperature, the surfaces of the dismantled optical components shall be inspected for the nature and extent of any change in the optical surfaces that could have occurred, using a magnification of ×4 to ×10 under dark-field illumination of 5 000 lx through a collimated light source or gooseneck fibre bundle light source, with a daylight-equivalent colour temperature.

5.4.2 Preliminary test 1

Prior to commencement of testing, all specimens shall be inspected for interior moisture caused by excessive humidity during assembly. The specimens shall be cooled at a test chamber temperature of −10 °C, long enough for all parts of the specimen to reach a temperature within at least 3 K of the test chamber temperature. The specimens shall then be heated immediately in a preheated test chamber at approximately 40 °C. The specimens shall be closely observed during heating, and any in which a coating of moisture appears, even briefly, shall be excluded from the test.

5.4.3 Preliminary test 2

In order to establish the warm-up time of the internal air during the cycling, sensing devices shall be mounted in a representative number of separate internal air spaces of the specimens. The time period to be measured is that required for the heating of the internal air in the changeover from step 2 to step 1 to a temperature within 3 K of the prescribed test chamber temperature in step 1. This time period shall be considered as the exposure time in step 1. If several sensing devices are used, the mean of the individual measurements shall be considered as the exposure time.

5.4.4 Condition 1

The instrument-specific exposure time in step 1 established in preliminary test 2 shall be kept to ± 10 % in order to avoid drying out of the instrument due to excessive exposure times. A tolerance of ± 2 min is admissible for exposure time < 20 min. The changeover from step 1 to step 2 or vice versa shall take place quickly enough to ensure that the specimen undergoes a temperature change not greater than 3 K. At the commencement of the test, the required warm-up time from the room temperature to 40 °C shall be added.

5.4.5 Conditions 2 and 3

The specimen shall be subjected to condition 2 immediately after condition 1. Transfer to condition 3 shall also be performed immediately. The specimen shall be constantly observed during the warm-up period in condition 3 (intermediate test). This is to establish whether, to what extent and over what time period, a coating of moisture occurs on the internal optical surfaces.

5.5 Procedure for conditioning method 48

5.5.1 Initial and final inspection

The initial and final inspection as described in 5.4.1 shall be carried out.

5.5.2 Preliminary test

The preliminary test as described in 5.4.2 shall be carried out.

5.5.3 Condition 1

The low-pressure container with the specimen shall be installed directly in the humidity chamber. The humidity chamber shall be set to the climatic conditions of step 2. The pressure appropriate to the required degree of severity shall then be set inside the low-pressure container and maintained for the duration of the exposure time required on step 1. In the changeover to step 2, the ventilation of the low-pressure container shall be performed using the circulated air of the humidity chamber. When the low-pressure container is opened, the specimen shall be maintained for the prescribed exposure time under the climatic conditions in step 2. This procedure is repeated two or five times (three or six cycles).

5.5.4 Conditions 2 and 3

Conditions 2 and 3 shall be performed as described in 5.4.5.

5.6 Procedure for conditioning method 49

5.6.1 Initial and final inspection

The initial and final inspection as described in 5.4.1 shall be carried out.

5.6.2 Preliminary test

The preliminary test as described in 5.4.2 shall be carried out. The specimen shall be evacuated after reaching the test temperature in condition 1. After the prescribed exposure time, the specimen shall be sealed and stored under the same climatic conditions for the duration of the exposure time as that prescribed for condition 2.

5.6.3 Conditions 3 and 4

Conditions 3 and 4 shall be performed as described in 5.4.5 for conditions 2 and 3.

5.7 Procedure for conditioning method 50

To achieve the test temperature, cooling shall be started before the pressure is reduced. The specimen shall have reached the specified test temperature before the test pressure is adjusted. Thermally active specimens shall be subjected to the test temperature until the temperature of the specimen changes not more than 1 K/h during constant test chamber temperature. Then, pressure reduction shall be started. Intrinsic heating of the specimen during this procedure shall be admissible.

The period of conditioning shall start when all parts of the specimen have reached a temperature within 3 K of the test chamber temperature and the specified pressure has been reached.

After completion of conditioning, condensed moisture or hoarfrost shall form on the specimen during pressure rise, as specified in the relevant specification. There are two methods of generating the formation of condensed moisture or hoarfrost on the specimen. One of the two methods described below shall be specified in the relevant specification.

a) Production of hoarfrost under low pressure conditions. Within the temperature range −20 °C to −10 °C and in the low pressure range from 400 hPa, water vapour is injected into the test chamber while heating is in process.

b) Production of hoarfrost under standard pressure conditions.

During heating, the pressure within the test chamber is adjusted to standard ambient pressure while the temperature is maintained between −20 °C and −10 °C. Moisture condenses and freezes on the specimen because of its low temperature. When hoarfrost is present, specimens that do not develop inherent heating shall be prevented from drying out during the final test.

The temperature shall be measured in the test chamber and on the specimen. The location of the temperature sensor on the specimen shall be specified in the relevant specification. The location of the temperature sensor for measuring the chamber air temperature shall be noted in the test report.

5.8 Procedure for conditioning method 51

To achieve the test temperature, cooling shall be started before the pressure is reduced. The specimen shall have reached the specified test temperature before the test pressure is adjusted. Thermally active specimens shall be subjected to the test temperature until the temperature of the specimen changes not more than 1 K/h during constant test chamber temperature. Then, pressure reduction shall be started. Intrinsic heating of the specimen during this procedure shall be admissible.

The period of conditioning shall start when all parts of the specimen have reached a temperature within 3 K of the test chamber temperature and the specified pressure has been reached.

After completion of conditioning, the rise in pressure is initiated simultaneously to the heating of the test chamber to ambient temperature. When the pressure is rising, no condensation shall occur on the specimen. Ways of preventing this are either the use of repurified nitrogen or dry air for the ventilation of the test chamber or radiant heating of the specimen.

The temperature shall be measured in the test chamber and on the specimen. The location of the temperature sensor on the specimen shall be specified in the relevant specification. The location of the temperature sensor for measuring the chamber air temperature shall be noted in the test report.

6 Environmental test code

The environmental test code shall be as defined in ISO 9022-1, giving a reference to this part of ISO 9022 and the codes for the conditioning method chosen, the degree of severity, and the state of operation.

EXAMPLE The environmental test of optical instruments for resistance to low ambient pressure combined with ambient temperature, conditioning method 45, degree of severity 02, and state of operation 2 is identified as:

Environmental test ISO 9022-45–02–2.

7 Specification

The relevant specification shall contain the following details:

a) the environmental test code;

b) the number of specimens;

c) the location and the number of the temperature measuring points;

d) the preconditioning in general and for conditioning method 47, taking account of 5.4.3;

e) the type and scope of initial test in general and for conditioning methods 47 to 49, taking account of 5.4.1;

f) the period of operation for state of operation 2;

g) the type and scope of intermediate test for state of operation 2 in general and for conditioning method 47, taking account of 5.4.5;

h) the recovery;

i) the type and scope of final test in general and for conditioning methods 47 to 49, taking account of 5.4.1;

j) for conditioning method 50, the time of first hoarfrost formation and the method of generation;

k) the criteria for evaluation, e.g. duration of moisture deposition, nature, and extent of any changes occurring on optical surfaces;

l) the type and scope of test report.

Annex A
(informative)

Explanatory notes

A.1 Conditioning method 47

Conditioning method 47 is intended to create conditions similar to those experienced, for example, in climates with frequent alternation between strong sunshine and rain. Instruments with poor sealing are particularly at risk here due to the penetration of humid air. The low internal pressure is caused by the change of the temperature.

A.2 Conditioning method 48

Conditioning method 48 is intended to simulate the conditions experienced by, for example, air freight. In the cargo compartments of aircraft, pressures as low as 500 hPa can occur during flight. On landing in areas with high humidity, equalization of pressure in the interior of the instrument can cause penetration of moisture particularly into instruments with medium sealing.

A.3 Conditioning method 49

Conditioning method 49 is not intended to simulate natural environmental conditions. It should be used primarily to establish sealing against humidity in instruments where sealing requirements are very high.

A.4 Conditioning methods 50 and 51

Conditioning methods 50 and 51 describe two methods of exposure characterized by different environmental influences. Both methods employ cold and low ambient pressure as relevant factors. Whereas conditioning method 51 requires only low temperature and low ambient pressure, conditioning method 50 also includes exposure to hoarfrost and condensed moisture.

Conditioning method 51 simulates the operation and transport of optical instruments in high mountainous areas where temperature and humidity change slowly without noticeably affecting the instrument. Similar conditions are encountered in unheated internal compartments of aircrafts where there is little or no pressure balance, e.g. in cargo space. Hoarfrost and moisture condensation can be excluded in such surroundings. However, optical instruments, or parts of them that are externally mounted on aircraft, are exposed not only to cold and low ambient pressure but also to air humidity in the form of condensed moisture or hoarfrost.

Condensation or freezing of moisture on instrument surfaces, or even within leaky instruments, occurs when descending aircraft or missiles penetrate regions where, with rising temperature and pressure, humid air or rain are encountered, the temperature of which exceeds the temperature of the instrument surfaces. The melting hoarfrost or the condensed moisture is likely to penetrate into externally mounted instruments or components. As a consequence of leakages or inadequately ventilated parts, condensed moisture can accumulate within the instrument and cause malfunctions.

Exposure conditions as required for conditioning method 51 can be simulated in standard low-pressure cabinets or chambers providing means of cooling and air circulation. If, for conditioning method 50, the formation of hoarfrost in the low pressure range is additionally required, the test apparatus should include a device for injecting, at low temperature and low pressure, water vapour and spray into the chamber; the injection inlet should be located near the specimen. One of several methods of performing the test in accordance with conditioning method 50, using a chamber as described above, is given in A.5.

A.5 Example of conditioning method 50

At the end of the exposure time and while heating up is in process, adjust the test chamber temperature to between −20 °C and −10 °C. Let specimen temperatures stabilize within this temperature range. Adjust the pressure within the test chamber to between 400 hPa and 600 hPa. Inject, in the immediate neighbourhood of the specimen, water vapour or spray through a well-insulated hose and funnel into the chamber until hoarfrost becomes clearly visible on the specimen. Then, as rapidly as possible, raise the chamber temperature to approximately 2 °C, at constant pressure, and dwell at this temperature until the wet bulb indicates a positive temperature value. This dwell time, which depends upon the type of humidifier used in the test chamber, is required because, normally, the humidity control will not work until the mantle humidifier installed within the test chamber has defrosted. The relative humidity within the test chamber is to be maintained at a level of more than 95 % in order to prevent the condensed moisture from drying while heating up continues.

As soon as the moisture control has started working and the relative humidity has reached a level of more than 95 %, adjust the test chamber temperature, as rapidly as possible, and at constant pressure and constant relative humidity, to ambient atmospheric conditions until the hoarfrost on the specimen has completely changed into condensed moisture.

After ambient atmospheric conditions have been reached, gradually adjust the test chamber pressure to standard pressure. The relative humidity within the test chamber should continue to be maintained at more than 95 %.

Care should be taken that the condensed moisture on specimens other than heat-active components does not dry up during the subsequent intermediate test.

Bibliography

[1] ISO 9022-2, *Optics and photonics — Environmental test methods — Part 2: Cold, heat and humidity*

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